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EDITORIAL NEOTROPICAL VEGETATION

Vegetation classification in the Neotropics – Novel insights from Latin America and the Caribbean

Gwendolyn Peyre[1], Bianca O. Andrade[2,3], Alejandro Velazquez[4], Melisa A. Giorgis[5,6]

1 *Departamento de Ingeniería Civil y Ambiental, Universidad de los Andes, Bogotá, Colombia*
2 *Department of Botany, Federal University of Rio Grande do Sul, Porto Alegre, Brazil*
3 *Department of Environmental and Life Sciences, Karlstads Universitet, Karlstad, Sweden*
4 *Centro de Investigaciones en Geografía Ambiental, Universidad Nacional Autónoma de México, Mexico DF, Mexico*
5 *Instituto Multidisciplinario de Biología Vegetal (CONICET-UNC), Córdoba, Argentina*
6 *Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba, Argentina*

Corresponding author: Gwendolyn Peyre (gf.peyre@uniandes.edu.co)

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Abstract

Our editorial introduces a Special Collection of scientific articles on current vegetation research in the most biodiverse of all biogeographic realms, the Neotropics. It contains nine scientific contributions dedicated to vegetation data, description and classification. Four research papers provide new vegetation classifications of important Neotropical biomes, namely the Arid Chaco in Argentina, Mexican temperate forests, and Andean wetlands in the Argentine Puna and southern Peru. Furthermore, one study provides a novel bioclimatic-vegetation classification approach applied to Mexican vegetation, while another proposes a new synthesis of the South American terrestrial biomes as geocomplexes. Finally, three vegetation databases are presented in the Special Collection: *ArgVeg – Database of Central Argentina* (GIVD ID: SA-AR-002), *CACTUS – Vegetation database of the Dutch Caribbean Islands* (GIVD ID: SA-00-004) and *VegAndes: the vegetation database for the Latin American highlands* (GIVD ID: SA-00-005). The Special Collection provides fundamental data and tools to better understand the diversity and complexity of Neotropical vegetation.

Abbreviations: GIVD = Global Index of Vegetation-Plot Databases, IAVS = International Association for Vegetation Science, IAVS-LACS = IAVS Regional Section for the Latin America and the Caribbean, VCS = Vegetation Classification and Survey

Keywords

Andes, Argentina, classification, database, Dutch Caribbean Islands, geocomplex, Mexico, Peru, vegetation formation

Background

The Neotropics extend from Mexico to Tierra del Fuego and contain around 85,000 vascular plant species, making it the most phytodiverse biogeographic realm on Earth (Ulloa Ulloa et al. 2017). The Neotropics encompass several renowned global biodiversity hotspots, including Mesoamerica, the Caribbean islands, the Tropical Andes, the Atlantic Forest and the Cerrado (Mittermeier et al. 2011; Peyre 2021). They also play a crucial part in maintaining essential ecosystem services that are vital to humanity and help uphold planetary boundaries (Rockström et al. 2009; Díaz et al. 2020). One primary example is global climate regulation through major carbon sinks in tropical rainforests and mountain ecosystems such as páramos (Brienen et al. 2015; Thompson et al. 2021). Moreover, by comprising the Mayan, Amazonian and Andean forests, the Neotropics ought to be considered the most diverse and extensive ger-

mplasm bank worldwide. The Neotropics have remained relatively preserved compared to other realms, partly due to their low population density and vast inhospitable landscapes. It is of the utmost importance to assess and predict human impacts to ensure our sustainable coexistence with nature in the future (Kobayashi et al. 2019).

The Neotropical realm was first described and classified according to its biogeographic regions by Wallace (1876), leading to numerous subsequent classifications based on plants and/or animals up to the present (e.g., Cabrera and Willink 1973; Morrone 2017). For instance, Rivas Martinez et al. (2011) recognized 50 biogeographic provinces, which they classified into 11 regions: Caribbean-Mesoamerica, Neogranadian, Guyanan-Orinoquian, Amazonian, Brazilian-Paranaense, Chacoan, Tropical South Andean, Hyperdesertic Tropical Pacific, Pampean, Middle Chilean-Patagonian, Valdivean-Magellanian (see Navarro et al. 2023, for a novel classification). Although there is still no clear consensus today, researchers are increasingly compiling information and producing useful phytoregionalizations, vegetation classification and vegetation pattern analyses. At a finer scale, the vegetation diversity in the Neotropics (Figure 1) can be associated with its unique biogeography, the complex evolution of its orogeny and soils, the immense floristic cradle, and more recently, human interactions. For example, the Andean páramo, covering 25,000 km^2 of tropical alpine habitats, harbors more than 500 plant communities alone (Rangel-Churio 2000; Peyre et al. 2021).

Despite the substantial body of research already published, the vegetation of the Neotropical realm remains poorly documented compared to others such as the

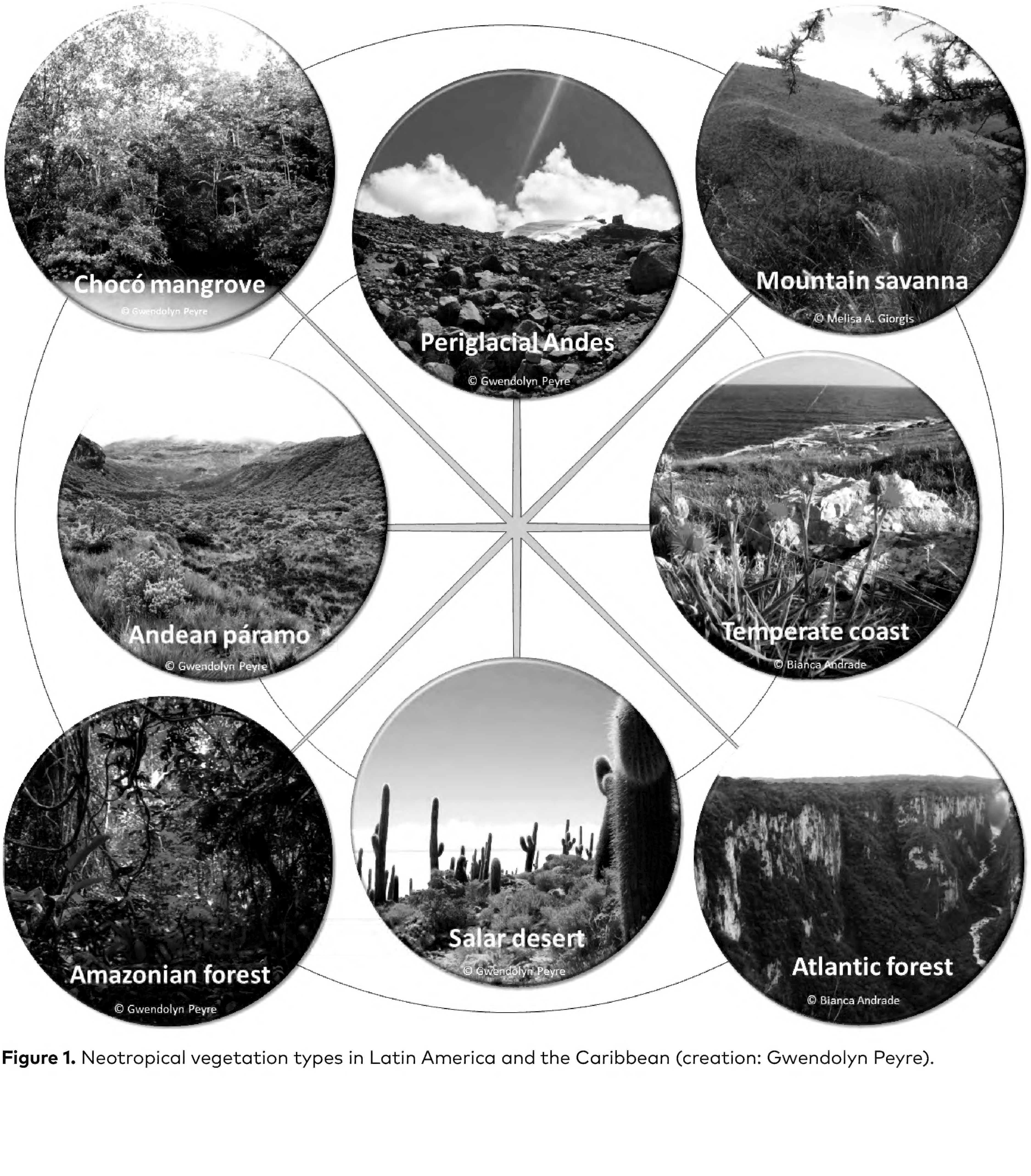

Figure 1. Neotropical vegetation types in Latin America and the Caribbean (creation: Gwendolyn Peyre).

Palaeartic, Nearctic, Australasian or Oceanian realms (Sabatini et al. 2021). Several factors contribute to this lack of information and we would like to highlight a few key ones. First, political instability and limited economic resources allocated to science are significant obstacles (Casas and Mercado 2015). For instance, in 2020, Latin America and the Caribbean invested 0.62% of their regional income in science, compared to 3.32% in North America and 2.28% in the European Union (Banco Mundial 2020). Second, the immense Neotropical biodiversity is challenging to synthesize due to the lack of integrated taxonomic studies and a high proportion of missing diversity. For example, Ecuador and Peru could harbor up to 30% of the total missing species worldwide, across all taxa, which can hinder our ability to conduct representative and comprehensive biological studies (Joppa et al. 2011). Additionally, other barriers such as data availability, data access and language barriers can also interfere with efforts to compile large repositories of neotropical vegetation information (but see the Special Collection for a few examples).

In 2022, Vegetation Classification and Survey (VCS) and the Latin American and Caribbean Section of the International Association for Vegetation Science (IAVS-LACS) partnered to launch this Special Collection dedicated to "Neotropical vegetation". This Special Collection aims to provide new insights into vegetation classification-related research across the Neotropical biogeographic realm. It focuses on vegetation classification/typology and/or ecoinformatics from three perspectives, (1) vegetation data, distribution, representativeness and access; (2) vegetation description, analysis and classification; and (3) vegetation management and conservation.

Content of the Special Collection

The VCS Special Collection comprises nine articles, including five Research Papers, one Review and Synthesis, and three Long Database Reports. We introduce the studies as follows:

Zeballos et al. (2023) provide an integral classification of the vegetation types of the Arid Chaco in Central-Western Argentina. The authors investigated the main vegetation types of the Arid Chaco, characterized their flora, endemism, chorotypes, and life forms, and associated them with environmental gradients. Based on 654 relevés, they identified nine vegetation types, with xerophytic shrublands being dominant. They highlighted the effects of historical and present land-use, conferring a clear Chaquenian identity to this area.

Ávila-Akerberg et al. (2023) conducted extensive work on the classification and nomenclature of temperate forest types in Mexico. The authors provide a comprehensive analysis and synthetic update of the nomenclature of sub-humid and temperate forests in Mexico. Through their research, they found that vegetation classification proposals tend to standardize criteria and nest hierarchical integrations at various levels based on physiognomic, climatic, phenological and floristic attributes. They established that physiognomy was a primary divider at a broader scale, whereas floristics typically divided at finer scales. Their work calls for a complete inventory of the phytosociological associations of temperate forests in the country.

Casagranda and Izquierdo (2023) contributed a novel study on modelling the potential distribution of floristic assemblages of high Andean wetlands dominated by *Juncaceae* and *Cyperaceae* in the Argentine Puna. Their aim was to model the potential distribution of *vegas*, high Andean wetlands, and their flora. Their models predicted that *Juncaceae*-dominated *vegas* were chiefly distributed in the Northern region, at high elevation, and in humid, cold conditions. In contrast, *Cyperaceae*-dominated *vegas* were mostly predicted in the southern region, at lower elevation and in drier, hotter conditions. The authors provided planning tools to better understand *vega* distribution under changing environmental conditions.

Gopar-Merino et al. (2024) provide a coupled cartographic approach between bioclimatology and vegetation formations of Mexico. This study represents a first attempt to unravel the intricate interplay between climate and vegetation and to unify a system for depicting Mexican vegetation patterns. Using a combined geobotanical and bioclimatological approach, the authors identified 13 distinct bioclimatic classes. When combined with physiognomic types, these classes depicted 11 forest, three shrubland and three herbaceous biomes. Their method can be used for classification and conservation initiatives focused on vegetation.

Maldonado-Fonkén et al. (2024) classified the plant communities of high-Andean *bofedal* wetlands across a trans-Andean transect in southern Peru. The authors sampled a nearly 70 km long transect in southern Peru and characterized its plant communities and flora. They identified seven different plant communities, often forming cushion and mat vegetation, dominated by *Distichia muscoides*, *Werneria pygmaea*, *Plantago tubulosa*, *Plantago rigida*, *Lachemilla diplophylla*, *Aciachne pulvinata* and *Juncus stipulatus*. Their findings highlight the *bofedal* diversity in the region and suggest new lines of research and management initiatives.

From a systematic angle, **Navarro et al. (2023)** have proposed an innovative synthesis titled "South American terrestrial biomes as geocomplexes: a geobotanical landscape approach". They associate vegetation units at the landscape level, showing how these units interact with each other and are conditioned by climatic, topographic and edaphic gradients within a geographic area. Based on this premise, the authors establish a conceptual framework that views the biome as a landscape complex (geocomplex), which includes vegetation geoseries that, in turn, comprise geomorphologically linked zonal and azonal vegetation series. Applying this framework to South America, they identified and synoptically

characterized 33 geocomplex biomes and 16 macrobiomes. The results will be summarized in a dataset for the scientific community.

The VCS Special Collection also promotes three new vegetation data initiatives for the Neotropical realm. **Giorgis et al. (2022)** have contributed "ArgVeg – Database of Central Argentina". This novel dataset, GIVD ID: SA-AR-002, includes 1,092 vegetation-plot records, containing 1,184 valid native and non-native vascular plant species (September 2022). The database covers the main vegetation types of the Chaco, Espinal and Pampa in central Argentina. It fills in an important data gap and highlights the outstanding plant diversity of central Argentina. The authors call for further contributions and networking towards a better understanding, conservation and management for these endangered ecosystems.

Janssen et al. (2023) present the repository "CACTUS – Vegetation database of the Dutch Caribbean Islands". The database, GIVD ID: SA-00-004, compiles vegetation-plot records from the Dutch Caribbean Islands, and currently contains 2,701 of these. The database can be used for vegetation classification in an undersampled and underrepresented region, tracking vegetation change over time, to assist in the planning of vegetation surveys, as a source for plant species distribution maps, and to inform nature conservation and policy.

Finally, **Peyre et al. (2022)** promote the novel dataset "VegAndes: the vegetation database for the Latin American highlands". VegAndes, registered under GIVD ID: SA-00-005, is an extensive dataset for georeferenced and standardized information on vascular plants in the Latin American highlands. The database compiles 5,340 vegetation plots sampled in 11 Latin American countries, with 5,804 taxon names, and spans over seven decades. Because the VegAndes data support multi-scale studies in botany, ecology and biogeography, it makes a significant contribution to biodiversity research and management in Latin America, especially considering the impacts of climate change on vulnerable tropical mountains.

Future perspectives

The diverse research featured in this VCS Special Collection suggests significant potential for collaboration among vegetation scientists from Latin America and the Caribbean and the IAVS journals, Journal of Vegetation Science, Applied Vegetation Science and Vegetation Classification and Survey. In 2019, the IAVS-LACS was launched, aiming to connect researchers dedicated to vegetation science in Latin America and the Caribbean. It is expanding rapidly due to its broad regional interest and outreach. Currently, the IAVS-LACS group is conducting an extensive bibliometric review on regional works, as an invited contribution to the Journal of Vegetation Science. This new initiative will help to identify knowledge, geographical and topical gaps and promote new initiatives and collaborations within and beyond the community. The growing need for understanding the impacts of global change on spatial and temporal variations in vegetation is particularly relevant for the Neotropics, and it calls for urgent measures to improve data availability and research.

Author contributions

GP planned and drafted this editorial, while all other authors contributed, revised and approved it.

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E-mail and ORCID

Gwendolyn Peyre (Corresponding author, gf.peyre@uniandes.edu.co), ORCID: https://orcid.org/0000-0002-1977-7181
Bianca O. Andrade (bianca.andrade@kau.se), ORCID: https://orcid.org/0000-0003-2945-1510
Alejandro Velazquez (avelazquez@unam.mx), ORCID: https://orcid.org/0000-0002-6353-2894
Melisa A. Giorgis (mgiorgis@imbiv.unc.edu.ar), ORCID: https://orcid.org/0000-0001-6126-6660